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Taxonomy of usage problems for improving user-centric online health information provision

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ABSTRACT (REQUIRED)

Consumer health information portals (HIP) are a popular means to provide quality health information via the Web. However complex usage problems in HIPs are still a major barrier to their success. A usage-driven approach, which places emphasis on improving online services based on learnings from the data of the interactions between users and the system, is crucial to ensuring sustainable and user-centred online health provision. Inspired by this idea, we present a taxonomy of usage problems that encompasses the dimensions of the content, the systems and users, focusing on a holistic understanding of usage problems. Our taxonomy is grounded on a literature analysis empirically validated through an analysis of usage-data captured from a consumer health information portal, operational for the past five years. By exploring how usage data highlights user problems, we also present strategies for health portal improvements based on better understandings of usage data. Benefits of usage-driven health portals in terms of smart learning capabilities to improve content and user satisfaction are discussed.

Keywords (Required)

ehealth, usage data, information retrieval, user-centred information provision

INTRODUCTION

Health information portals (HIPs), commonly known as one-stop shops for quality online health information, are perceived as increasingly important today as a means of empowering health consumers (Fisher, Burstein, Lynch, Lazarenko and McKemmish, 2007). However, information searching in HIPs is far from being effective (Fisher et al., 2007). Multiple problems hinder users from finding the right information, including problems of content management, information quality, and health consumers' information seeking skills (Fisher et al., 2007; Zeng, Kogan, Plovnick, Crowell, Lacroix and Greenes, 2004). Online information seeking is further complicated because often more than one factor involved.

The literature reports that online health information seeking is more complex than just a domain-specific information searching (Keselman, Logan, Smith, Leroy and Zeng-treitler, 2008; Zeng et al., 2004). Often highlighted is the mismatch between online health systems and the needs and skills of health consumers. It is widely recognised that consumers have complex, changing and heterogeneous information needs (Find/SVP, 1998) ranging from health advice, treatment or prevention information, seeking for different types of resources from expert advice to community opinions. However, online health information especially in health portals is at times subject to tight quality management and review processes, which pose many challenges in keeping up with users' needs (Fisher et al., 2007).

Individual issues with health information seeking is well studied, however the bigger picture of usage problems and how a better understanding of usage issues might lead to improved online health systems design is less well researched. Our focus therefore, was on examining usage problems from a broader perspective. In particular, problems relating to the interaction between users, health content and online health systems. While acknowledging the commonality of online usage problems, we position our research in online health information portals specifically as recent research highlights increasing interest in the area from the user and usage perspective (Burstein, Fisher, McKemmish, Manaszewicz and Malhotra, 2005).

This research focuses on a usage-based approach. The trend towards data-driven and consumerization of the Internet increasingly exploits the vast quantity of usage data, either generated by users or captured automatically and used to improve services. Examples include E-commerce sites such as Amazon.com or social networking sites where data on users' purchasing behaviour is stored and later used for commercial gain. We argue that online health information systems are no exception. Learning from usage promotes self-adapting and smart learning capabilities, such as to provide content suited to

users' needs or to identify and address points of user dissatisfaction. Consequently it can lead to more sustainable and user-centred health information provision. Therefore in this paper we sought to examine the interaction between users and the systems through automatically captured data, rather than traditional methods such as surveys or interviews.

This paper presents a taxonomy or classification of usage problems grounded on a literature analysis and empirically validated through the examination of usage data. Second, we illustrate its applicability through a taxonomy or framework which proposes how to address problems through a usage-based approach.

The next section reviews the major problems in online health information provision. We then present the research methodology. The taxonomy and results of the validation are discussed, followed by recommended strategies for addressing identified usage problems in online health systems. Finally we discuss the implications of this work in particular the impacts in terms of improving and sustaining health information provision. It should be noted that while the case presented applies to the health domain the outcomes have wider applicability.

ONLINE HEALTH INFORMATION PROVISION

Online health information provision is increasingly perceived as having a significant impact on consumers' healthcare, notably in providing effective healthcare knowledge, enhanced medical decision making and eventually improved public health outcomes (Cline and Haynes, 2001; Keselman et al., 2008).

The literature discusses a wide range of issues relating to online health information website usage. In the context this research we focus on problems pertaining to three major actors: the users, the content and the systems as articulated by (McCray and Tse, 2003).

Research on online health content has traditionally focused on quality issues. In constructing our taxonomy we also incorporated Berland *et al.*'s (Berland, Elliott, Morales, Algazy, Kravitz, Broder, Kanouse, Muñoz, Puyol, Lara, Watkins, Yang and McGlynn, 2001) view on other problems of online health content, including accessibility, readability and quality. Sufficiency of relevant health content is another notable research theme, particularly important to sustainable online health information provision (Benigeri and Pluye, 2003). (Keselman et al., 2008) reports on the diverse and broad range of user health information needs, signifying the need to address diversity concern in online health content.

The major system problems include: deficiencies in health-specific information retrieval mechanisms, personalization, user interface and health website usability. Online health information retrieval also requires language support, user-friendly term indexing and some form of quality indicators (Keselman et al., 2008; Zeng, Kogan and Ash, 2002). Despite the available technologies, research reveals that health consumers still find the websites difficult to use or ineffective for searching for health information (Fisher et al., 2007). Approaches to address systems problems in online health also tend to have a strong emphasis on domain-specific mechanisms to provide personalized, differentiated information access (Burstein et al., 2005; Fisher, Burstein, Manaszewicz and Lazarenko, 2009).

Finally, user issues in the health domain are well-researched, covering such areas as linguistics/medical query terms (Zeng et al., 2002), heterogeneous information needs (Josefsson, 2006), health literacy (Kogan, Zeng, Ash and Greenes, 2001), user information behavior (such as search strategy and user effort) and relatively low user proficiency in information processing skills (Zeng et al., 2004).

METHODOLOGY

A two-stage process was used to construct the taxonomy iteratively, first by a literature analysis and followed by a usage analysis (coding of use cases) to refine and validate the taxonomy. A number of measures were used to ensure the reliability of data analysis.

Literature Analysis

The literature analysis identified the basic taxonomy framework and identified common problems of online health information. The literature analysis included papers discussing problems of usage in consumer health information provision. The general structure and key themes forming the taxonomy emerged from the analysis. Major categories were created or grouped together until no more categories new appeared (Figure 1). The taxonomy was reviewed and refined iteratively through this analysis.

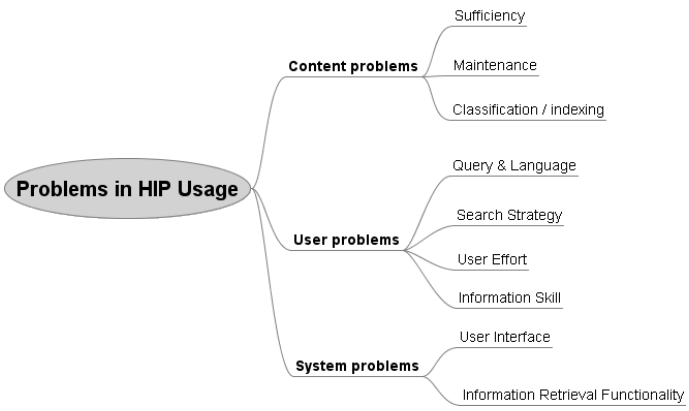

Figure 1.Key usage problems from the literature analysis

Coding of usage data

Our objectives for the usage analysis were to:

- taxonomy validation and refinement
- assess the problems empirically, explore to what extent they can be detected from analyzing usage data and learn about their distribution
- explore the link between observed problems and possible problem-solving strategies to improve online health systems through a usage-based approach

The usage data for this study were collected from a specialised healthcare information portal - Breast Cancer Knowledge Online (http://www.bckonline.monash.edu.au -BCKO), an Australian user-centred personalised health information portal for breast cancer. BCKO is a good model of a consumer health website, providing quality-controlled health information, evaluated by a panel of domain experts, for a diverse range of users including early / recurrent / advance cancer patients, families or carers.

Data capturing covers from 5 March 2008 – 31 August 2009. The original data source includes over 300,000 entries. Of these, 400 search cases with failed outcomes (defined below) were sampled for manual classification. Captured data included queries, user profile (preferences), search options, search modes, click-through data (e.g. access to result pages), search refinement, search outcomes. We also replicated search cases with relaxed search options to determine all relevant content for a given search.

Usage data analysis as a method is consistent with other research (Bernstam, Herskovic and Hersh, 2009). We acknowledge that there are certain limitations, particularly reliability concerns since users' needs and experiences can only be understood indirectly (McCray and Tse, 2003). However, there are certain advantages justifying our methodological choice. In particular, usage-data based analysis allows us to approach the problems from a more comprehensive and non-intrusive way compared with other data collection methods.

The design of usage data coding was modeled based on previous research such as (McCray and Tse, 2003). The main difference is that while previous research was only limited to the analysis of query failures, we covered more types of usage data and therefore we were able to study a wider range of usage problems. On examining an issue, we are able to inspect both the properties of the content, the behavior of users or the response of the system to determine who is at fault. Usage-based approach is also in line with our chosen strategy for addressing problems in online health information as discussed in earlier section.

To address reliability concerns, a number of tools and guidelines (Table 1) were employed to assist in the manual coding process.

1.	To decide if it is a user issue, we asked "could the search be improved if the user had tried alternative ways to search?" We looked at the user effort (number of search actions), user strategy (whether the user employed different search modes or search options), search query
2.	To assess content issues, we relaxed the search to see if there is any relevant content. First search options are removed, and the more specific keyword is removed to broaden the search (e.g. from "pregnancy and breast cancer" to "pregnancy").
3.	To decide if a query is in-scope, we used Google search and examined if the results were relevant to the context (breast cancer or cancer).
4.	User *search strategy* was operationalised as the following: (i) trying alternative query terms (ii) trying different search modes (iii) trying different search options
5.	To determine if a search bears medical or scientific terms, we checked the query in MESH (a medical controlled vocabulary at The National Library of Medicine).
6.	Multiple codes can be applied to a case if necessary.

Table 1.Guideline for coding usage data

Coding procedure

To identify usage problems, we sampled problematic use cases, which were classified as follows: (i) no-result from the search, (ii) too many results (broad searches that returned all results), (iii) abandoned search (the user left after a single search). The nature of search failures observed (i) the intent of the user expressed by the query (ii) the interaction of users (iii) the amount of effort from users (iv) the outcomes of the searches were noted (Figure 2).

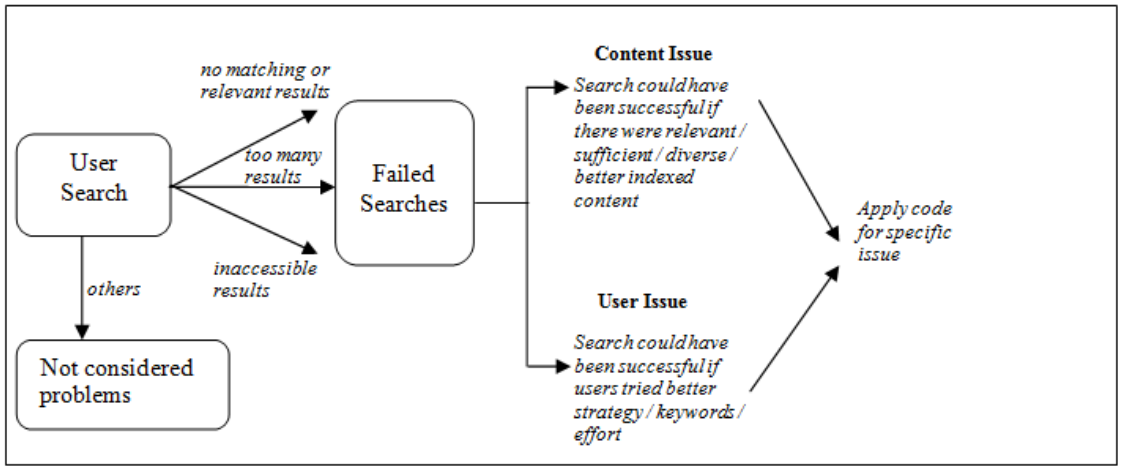

Figure 2. Decision tree for classifying usage problems

A multi-faceted data analyzer tool (Figure 3) was developed integrating different aspects of usage data pertaining to the users, the content, the responses of the system and the interactions among them. To examine content problems, information such as how much content there was, search outcomes, search relaxation were presented. The examiners may also need to consult external tools such as MESH index or web search to disambiguate especially medical concepts (included in the guideline below). Two annotators were used to increase the reliability of coding. In ambiguous cases, the classification is discussed until a consensus has been reached.

Figure 3.Screenshot of usage log analysis tool

As far as possible objective evidence was used for the data analysis. However, as the focus was on discovering the phenomenon behind an issue and to align it to the proposed taxonomy, the emphasis was not as much on the technical precision of the coding. Table 2 details the coding outcomes and the supporting research, it should be noted that not all papers drawn on for this stage of the research are listed, Table 2 contains the key references and those representative of the literature consulted.

	Code & Description	Supporting Research
Content Problems	**C1.** Insufficient content for a specific health information need	(Benigeri and Pluye, 2003; Cline and Haynes, 2001; Kogan et al., 2001)
	C2. No information category or a general content topic	(Cline and Haynes, 2001)
	C3. No permanence or maintenance of content	(Burstein et al., 2005)
	C4. Overloading of irrelevant or low-quality content	(Kogan et al., 2001)
	C5. Misclassification / mis-indexing of information content (e.g. misuse of terminology in indexing)	(Josefsson, 2006)
	C6. Lack of information diversity to cater for heterogeneity of health information needs	(HONSurvey, 2006)
	C7. Scientific complexity in content	
User Problems	*Query & Language*	
	U1. Layman terms or inaccurate scientific query	(Zeng et al., 2002)
	U2. Misspelling	(McCray and Tse, 2003)
	U3. Out-of-scope query	
	Search Strategy	
	U4. Single search strategy	(Eysenbach and Köhler, 2002)
	U5. Confusion with use of search tools or query composition	(Keselman et al., 2008)
	U6. Use of overly-scientific or medical terms	(Zeng et al., 2002)
	U7. Use of broad or too general terms	(Zeng et al., 2004)
	U8. Limiting search with narrow options or narrow topics	(Fisher et al., 2007)
	User Effort	
	U9. Low persistence in search	(Herskovic et al., 2007)
	U10. Low flexibility to relax search	(Zeng et al., 2004)
	User Information Skill	
	U11. Mental model, unclear intent when expressing needs	(Zeng et al., 2002)
	U12. Consumer health literacy	(Keselman et al., 2008)
	U13. Misunderstanding results, search abandoned	(Kogan et al., 2001)
System Problems	*User Interface*	
	S1. Result overload	(Fisher et al., 2009)
	S2. Readability of results	(HONSurvey, 2006)
	S3. Medical jargon used without language tools	(Fisher et al., 2009)
	S4. Usability of website	(Marill, 2001)
	Functionality	
	S5. Limited search power	(Soualmia and Darmoni, 2005)
	S6. Complexity of search tools without proper explanation	(Fisher et al., 2007)

Table 2.Taxonomy of usage problems in online health information and literature

TAXONOMY OF USAGE PROBLEMS

The taxonomy was based on the approach of McCray *et al.* (2003) focusing on three key aspects of online health information usage: content, the user and the system. Content issues are broader issues often not studied. Previous studies have

traditionally skewed towards users or system problems (for instance, user information needs or their information seeking skills). Therefore, we have extended the coverage of usage problems in our taxonomy in a more comprehensive way.

Result

The results for each of the three usage problems presented in Table 2 are discussed next. The results are presented as a percentage of problems identified through the usage analysis for each of the codes defined in Table 2.

Content Problems

Issue	C1	C2	C4	C5	C6
Percentage (n = 400)	25.96%	16.84%	10.18%	36.49%	23.86%

Table 3.Percentage of content problems in usage data coding

While the literature reports a lack of relevant online health content in general, we suggest that it may be beneficial to distinguish the lack of content for a specific information need (C1 – 25.96%) and that for an information category (C2-16.84%). For instance, searches for treatment cost / finance-related information emerged from our analysis without any content to serve them, which may prompt the addition of a new information category for these needs (as opposed to adding certain missing documents in the case of C1). Finding effective automatic techniques to differentiate C1 and C2 will be of benefit in the maintenance of the content to better meet user needs. C6 (problems with information diversity – 23.86%) is a serious issue for user-centred health information provision; that is, the content exists elsewhere but not for a particular group of users. C4 (overloading of irrelevant content – 10.18%) was apparent with a number of searches, especially searches with a broad query, overload users with irrelevant content. Regularly reviewing usage is one of the strategies that can be effective to address these problems as suggested in the next section. C3 (expiry of external links) and C7 (scientific complexity of content) is not examined due to limited data.

The most prevalent content problem identified is C5 (indexing problems – 36.49%). A number of cases in our usage examination showed that while the content exists, the indexing prevented users finding it. While there are increasingly more efforts to provide sophisticated indexing and information tailoring mechanism to customize to user needs (Burstein et al., 2005), such mechanisms might lead to inaccessible results for users.

We also noted the recurring nature of content problems where a one-off fix may not be appropriate. As user needs change a mechanism to review content problems and improve systems are important for the sustainability of eHealth websites.

User Problems

Issue	U1	U2	U3	U4	U6	U7	U8	U9	U10	U11
Percentage (n = 400)	2.46%	3.51%	4.56%	26.67%	19.30%	29.12%	27.37%	36%	10.88%	17.89%

Table 4.Percentage of user problems in usage data coding

User problems were confirmed in our analysis. A high number of cases used short and simple strategies (U4 - 26.36%) or had low persistence (U9) (36% with an average session length of 2.1) with users reluctant to relax their search (U10 – 10.88%). In conjunction with these, health-specific user search problems are a particular concern, including U6 (using overly-scientific, medical terms or narrow keyword), U7 (using generic or broad terms) and U8 (limiting search with narrow options or narrow topics). While user problems are also common in web searching generally, it is a bigger issue in online health searches because users often need to combine multiple strategies to reach more relevant results, given that relevant health information for a particular user's need is often difficult to find (Benigeri and Pluye, 2003). U5 (confusion with the use of search tools) was not included as this would require a deeper user study.

In several cases the users were not able to express their search intent effectively. Health information needs are complex with multiple ways to express them. For instance, searching using the query "massage" returns no results, although if the user tried another keyword search such as "therapy" it would result in more results. Finding relevant information is more difficult if the information need is an uncommon health topic (similar to C1 or C2), which may be difficult to express in a query or natural language.

The intertwining of problems: who's at fault?

Often it was not possible to single out a problem category. A problem occurs sometimes because both the content (or the system) as well as the users contributed to the failed search result. Search failure is amplified when users experience deficiencies from the content or the system and at the same time lack skills or strategies to rectify the problems. Problems that are likely to occur together emerging from the analysis include:

- U4 (simple strategy) is prevalent (26.36%) and co-occurs with other problems
- C1 and C2 (lack of content) tends to co-occur with U6 (medical / scientific query) (15.2% and 13.6% respectively): a search failure is caused both by the system having no content and users having a specific, narrow or scientific information need
- C6 (diversity of content) and U8 (narrow search options) co-occurs (12.4%): some content exists but not for the particular information preference the user requested or specified through filtering option
- C4 (irrelevant content) tends to co-occur with U7 and U11: if the search term is broad or the user's intent is not clear, and the content contains a high number of irrelevant resources, the search result is usually overloaded.

The intertwining of problems further complicates online health provision problems and has not been well researched. The results suggest a user-focused or content-focused solution alone may be insufficient suggesting a comprehensive solution strategy is required.

Finally, system problems are crucial to the success of online health systems, particularly to problems with usability, system design and information retrieval. (Fisher et al., 2009) provided an assessment on system problems, including features such as personalization, user interface and search functionality, and suggest improvements for the user search experience. System problems are included in the taxonomy due to its importance and for completeness, these however cannot be validated because of the usage analysis method selected.

TAXONOMY APPLICATION: A FRAMEWORK FOR USAGE-BASED STRATEGY TO ADDRESS PROBLEMS OF ONLINE HEALTH INFORMATION PROVISON

Given the problems established through the usage data analysis these insights are valuable either as decision-support tools (for the content managers) or user support tools to improve online health information searching. For example, through understanding content problems specific gaps of user needs can be identified and used to find new content, create new information categories, or update existing content. The taxonomy can be used as a framework to guide a usage-driven problem solving process in online health information.

The framework (Table 5) recommends actions to address the problems. There are two foci in the framework. First, it is an issue-driven framework linked to the taxonomy thus validating its applicability and problem-solving capability. Second, it embraces a usage-based approach focusing on interventions utilizing usage data. Table 5 includes examples of the problems. The evaluation of the framework is part of on-going research and therefore not discussed further in this paper. Improving system functionality (S5-6) is a complex subject and is also not within the scope of this discussion.

Problems	Examples	Recommended Actions
Lack of content C1, C2, C6	A user enters "*calcification*" or "*micro calcification*" receiving **no** results; three items exist but were not identified because of the indexing. This is a **recurring** issue. The search history confirmed users' serious intent and effort with search modifications when the first search failed. A user searched for "*research on hormone positive breast cancer*": **no** results (search history confirmed user intent); **no** content exists even with relaxed search options,	Identify gaps between the content and unattended searches - identify topic of interests but failed outcomes especially emerging / recurring failed searches. New categories may be created (C2)
Lack of permanence C3	Expired links	Identify expired links through analysis of "bounce-backs" in usage history
Irrelevant content C4		Based on usage access statistics, review unvisited content; review searches with too many results to improve precision
Indexing problems C5	User searched for "*herceptive*": **no result.** 36 relevant resources exist. Reason: resources narrowly-indexed (*scientific* content only), users elected non-scientific option.	Usage-driven indexing based on real search; acquire user-generated terms for indexing.
Complexity of content C7		Based on users' feedback, review complexity and readability of resources
Query & Language U1,U2,U3	User used "*chemo*" instead of "*chemotherapy*" (layman's term) "*angela"* (unknown intent, potentially out of scope)	Identify common query faults in usage logs to improve language support tools (such as spell check/thesaurus, 'did you mean?')
Search Strategy U4-8	1. *"invasive ductal carcinoma"*(very scientific query). **No result.** User continued using scientific queries (no change of strategy) 2. "surgery" (too broad) – user did not explore other strategies	Utilise usage data to as a source for recommending tools (such as "others also tried this..." feature)
User effort U9, U10		Provide usage-based hints for users with low persistence
Information skills U11,U12,U13	User searched for "*services*" and abandoned the search (unclear intent)	Utilise user feedback to improve resource accessibility, (such as readability)
UI Problems S1-4		Analysis of user navigation patterns to improve design and interface Longitudinal usage analysis to validate design changes

Table 5. Recommended Usage-based Actions with Examples

DISCUSSION AND CONCLUSIONS

This research contributes to a better understanding of HIP problems through a usage based analysis of prior research and empirical data from an operational portal. The results have practical benefits for health website designers/developers and content managers. The taxonomy detailing HIP usage problems creates a mechanism for usage-based improvements for more sustainable health information portals. Such a taxonomy provides a clear understanding of users' problems with HIPs and a way to address these problems in a proactive way, thus improving users' satisfaction. Some strategies derived, based on the taxonomy are offered in this paper, more are being investigated. Two key strategies identified are:

- Smart learning capability: learn from usage problems, towards automatic mechanism for detecting problems; present the portal owners with efficient mechanism to review and address content problems.
- Coping with the changing needs of users: the taxonomy highlights problems relating to the mismatch between content and user needs. A usage-based mechanism can alert the portal's manager about existing gaps between the content with users' needs, focusing on specific areas of health information (such as emerging health topics, narrow, specific information need). Understanding users' needs is a crucial criterion to ensure user satisfaction (Fisher et al, 2008).

Even though there is concern with the reliability of usage data, it is a scalable, non-intrusive data collection method, suitable as an automated means for collecting and analyzing the level of users' satisfaction with the online system and content (Jansen 2006), thus is an effective tool for monitoring usage in the longer term. Using such data for improving HIPs contributes to longevity of such portals.

This work also benefits user-centred health information provision. There are many potential problems arising from an "information tailoring" mechanism which user-centred approaches embrace, such as problems with indexing, content selection, personalized search. Many of those features rely on manual processes performed by domain experts (such as content review or indexing). This taxonomy facilitates systematic mechanism to review and address potential problems, promoting user-centred information provision.

Limitations and Future work

One limitation is the usage data analysis methodology. Current usage data analysis does not include underlying situational, cognitive or affective elements of usage (Jansen, 2006). Other dimensions of usage such as users' reflections on their experience were not included. Consequently, we only focus on problems that are more verifiable. While a large part of the taxonomy can be validated using usage data analysis, the results will be more reliable and perhaps more extensive if for example, user feedback or surveys were incorporated (similar to those used by (Madle, Kostkova, Mani-Saada and Roy, 2006)).

With regards to the comprehensiveness of the taxonomy, future research could extend the work to other usage problems such as the information use environment (such as language or culture), accessibility or users' perceptions and attitudes. We however anticipate that given the particular concerns of these in eHealth the central focus would still be on user interaction problems and the information content or the system. Finally, our taxonomy illustrates to some extent the potential of bridging the trend of data-driven / usage-driven research and extensive research on health information needs. These emerging trends have significant potential in addressing online health information problems and are worthy of further research.

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